

Section I

Intel ATX Specification 2.01
1996

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ATX Specification

Version 2.01

New features and additional requirements of Version 2.01 of the ATX specification

Please Note

Version 2.01 of the ATX Specification incorporates clarifications and some minor changes, as noted below. These changes take into account support for the next generation of ATX motherboards, while maintaining compatibility with the first generation. Readers should examine their combination of motherboard, power supply, and chassis needs to determine whether they require the additional features found in Version 2.01 of the ATX Specification.

Changes from Version 2.0 to Version 2.01 of the ATX Specification

- Section 2 - Updated Figure 1 to reflect recommendations implemented with Version 2.0.
- Section 3.2 - Modified Figure 2 to clarify motherboard mount requirements.
- Section 3.3 - Updated table of requirements to reflect changes in the section outlined below.
- Section 3.3.5 - Rewrote text to clarify requirements.
- Section 3.3.5 - Reduced keepout zone requirement to 0.1" (2.5 mm). This change was based on feedback from chassis manufacturers and is the most significant requirement change with respect to the chassis.
- Section 3.3.5 - Added recommendation to avoid paint within the keepout zone.
- Section 3.3.5 - Replaced Figure 4 to clarify chassis I/O aperture requirements. Tolerances were added to dimensions.
- Section 3.3.5 - Changed Figure 5 to define connector placement limitations on the motherboard. This is a new recommendation for motherboard designers to ensure clearance between the chassis and motherboard connectors for the I/O shield.
- Section 3.3.5 - Modified Figure 6 to remove redundant dimensions, and removed Figure 7 completely.
- Section 4.3.2 - Completely redefined FanC signal description, and removed Figure 15 completely.
- Minor edits have occurred throughout the document to improve readability and to correct minor typographical or grammatical errors.

Changes from Version 1.1 to Version 2.0 of the ATX Specification

- Section 3.2 – Changed the optional mounting hole to a required hole in chassis implementations. Changed a previously required mounting hole to “not needed.”
- Section 3.3.5 – Added information and drawing to clarify I/O aperture requirements. Added corner radius information to the specification for clarity
- Section 3.4 – Changed height restrictions to facilitate future processor and onboard technologies.
- Section 4 – An explanation of the intent regarding the direction of air travel for cooling. Removed the external fan shown on the drawing of a suggested ATX power supply. Added a caution about external power supply fans. Added comments and drawings for duct mounting.
- Section 4.2 – Added explanations for PS-ON, PW-OK, 5VSB power supply lines. The 3.3 VDC power rail and soft-power control signals are being changed to required.
- Section 4.3 – Added optional power connector for fan control, fan monitor, IEEE-1394 voltages, and remote 3.3 volt sensing.
- Section 4.4 – Added a section to give a suggested color coding for power supply wiring.
- Section 4.5 – Added a section suggesting a venting solution for power supplies.
- Section 5 – Added chassis considerations.
- Added tables throughout the specification for clarification and easy reference of recommended and required features.

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Version 2.01, February 1997

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1. Executive Summary

ATX was developed as an evolution of the Baby-AT form-factor and was defined to address four major areas of improvement: enhanced ease-of-use, better support for current and future I/O, better support for current and future processor technology, and reduced total system cost.

ATX combines the best functionality from the form factors that dominated the computer industry in the early 1990's: the high integration of LPX and the expandability of Baby-AT. The ATX form factor is essentially a Baby AT motherboard rotated 90 degrees within the chassis enclosure and providing a new mounting configuration for the power supply. The processor is relocated away from the expansion slots, allowing them all to hold full length add-in cards. The longer side of the board is used to host more on-board I/O. Table 1 provides a summary of ATX features.

A change to the system form-factor is ultimately of little benefit if it doesn't reduce overall system cost. ATX has achieved cost reduction in a number of ways:

- Material cost of cables and add-in cards is reduced because more I/O can be integrated down onto the board and because the hard drive and floppy connectors can be better positioned, allowing the use of shorter cables.
- Another benefit of integrated I/O down is the potential for lower EMI emissions with the removal of serial and parallel cables that can act like antennas.
- Manufacturing time and inventory holding costs are reduced because the number of cables in the system is reduced.
- Video-playback enhanced graphics and audio, the main hardware building blocks to support multimedia, are becoming a standard on many PCs; at the entry level, these features are quickly becoming a commodity. To reduce cost in a highly dollar-sensitive market segment, it makes sense to migrate these features down to the motherboard itself.
- By using a power supply that is specially optimized for ATX, it is possible to reduce cooling costs and lower acoustical noise. An ATX power supply, which has a side venting, allows direct cooling of the processor and add-in cards, making a secondary fan or active heatsink unnecessary in most system applications.

The ATX specification is written as an open specification for the industry, designed to add value to PC architecture.

Table 1: ATX Feature Summary

Feature	Benefit
Double height flexible I/O panel allows higher integration	<ul style="list-style-type: none"> ○ Lower system cost ○ Fewer cables ○ Improved reliability ○ Shorter assembly time ○ Support for future connectivity and I/O standards like USB, TV in/out, ISDN, etc. ○ Integrated graphics allows use of unified frame buffer architecture
Relocated drive I/O means shorter cables	<ul style="list-style-type: none"> ○ Reduced cost ○ Support for faster drives such as PIO Mode 4/5 IDE drives
System cooled by single fan in the power supply	<ul style="list-style-type: none"> ○ Reduced cost ○ More ergonomic (Reduced noise) ○ Improved reliability
Relocated processor and memory	<ul style="list-style-type: none"> ○ All full length expansion slots ○ Ease of use, upgrading the processor ○ Ease of use, upgrading memory ○ Ease of use, adding cards ○ Relocated processor allows easier use of bulk capacitance and voltage regulation circuitry

2. ATX Form-factor Overview

The ATX form-factor improves upon Baby AT and LPX in a number of ways. Because the power supply orientation and specification are modified, and the Baby AT motherboard is rotated through 90 degrees, the processor can be relocated away from the expansion slots, and the longer side of the board can be used to host more on-board I/O. The ATX power supply, rather than blowing air out of the chassis, as in most Baby AT platforms, provides airflow through the chassis and across the processor.

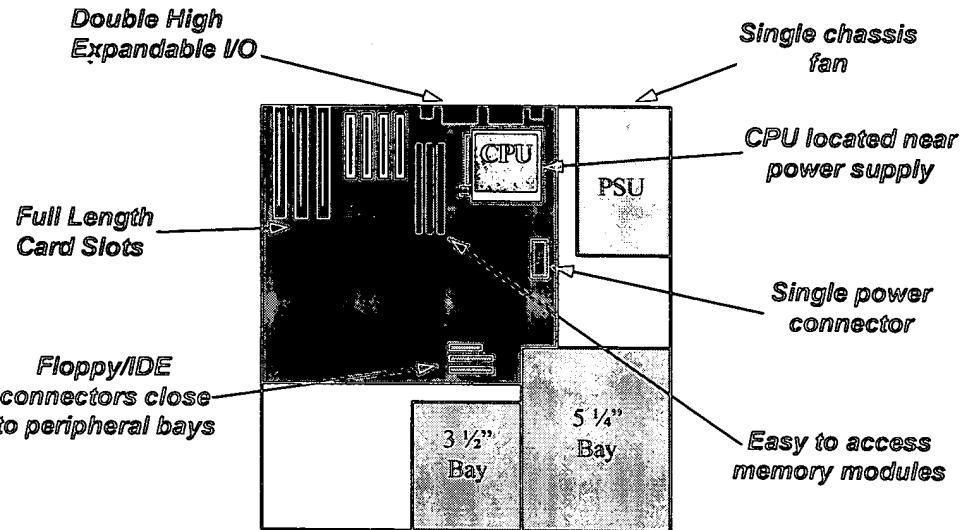


Figure 1: Summary of ATX Chassis Features

2.1 Improving the End-user Experience

By providing a 90 degree rotation of the board within the chassis, the specification gives the end-user benefits in ease-of-use and improved functionality.

- With the processor relocated, all expansion slots can be full-length.
- Because the processor is not located between or under the add-in cards, a processor upgrade can now be done without removing the installed cards.
- The SIMM connectors can be relocated away from the expansion bays and slots, increasing ease-of-use by giving easy access to the user for memory upgrades, and increasing the total number of available full length slots.
- The use of only a single fan within the system can reduce acoustic levels.
- More I/O is integrated onto the motherboard, improving reliability and reducing the number of cables.
- Disk I/O connectors are located closer to the peripheral bays, reducing cable lengths. This reduces clutter in the chassis and allows the use of faster hard disk drives.
- With increased ease of use, and a reduction in cable complexity, the technical support burden is lowered.

2.2 Benefits to Manufacturers

As well as improving functionality, the ATX form-factor also reduces total system cost. This is achieved by moving more I/O onto the motherboard and reducing the number of fans and cables within the system, cutting material and installation cost. The mounting hole positions for the ATX form-factor motherboard were carefully chosen to be backward-compatible with previous form-factor generations. Where possible, ATX utilizes the same mounting holes as Baby AT and full AT, simplifying the design of multipurpose chassis. For full details about the mounting holes, see section 3.2.

Another benefit is the potential for reduced EMI emissions through the use of integrated I/O connectors on the motherboard. Baby AT designs require that parallel and serial I/O off the motherboard be cabled up to connectors on the chassis back-panel. These cables, not required on ATX motherboards, may act as antennas that pick up and radiate unwanted EMI in Baby AT designs.

ATX has been designed with headroom for the future:

- An ATX board measures 12" x 9.6" (305mm x 244mm). This size allows a manufacturer to cut two printed circuit boards out of every 24" x 18" (660mm x 457mm) panel.
- A smaller ATX form-factor, Mini-ATX, may be implemented. The Mini-ATX board measures 11.2" x 8.2" (284mm x 208mm). This size allows a manufacturer to cut four printed circuit boards per 24" x 18" (660mm x 457mm) panel, reducing the cost of the printed circuit board by approximately 30%.

To standardize the inevitable migration towards this cost-reduced future form-factor, Mini-ATX is fully defined in this specification alongside full ATX.

3. Layout

The following section describes the mechanical specification of the ATX form-factor motherboard, including physical size, mounting hole placement, connector placement, and component height constraints. Where appropriate, details of the Mini-ATX form factor are also included to enable chassis manufacturers to plan now for this future development.

3.1 Board Size

The maximum allowable width for an ATX board is 12 inches (305mm), the same width as a full AT board. This width allows many existing AT form-factor chassis to accept Baby AT, Full AT, ATX, or Mini ATX form-factor boards with a minimum number of changes. A full size ATX board is 12 inches wide by 9.6 inches deep (305mm x 244mm). The Mini-ATX board is 11.2" x 8.2" (284mm x 208mm).

3.2 Mounting Hole Placement

Table 2: Motherboard Mounting Hole Locations

Feature	Status	Comment
Motherboard mounting hole locations	Required	See Figure 2 for an overview and Figure 3 for exact locations. All ATX board mounting locations shown should be implemented for full ATX 2.01 compliance.

Where possible, the ATX mounting holes line up with mounting holes used for Full AT and Baby AT boards. Three new holes have been defined and added to provide mechanical support along the front edge of the full size ATX board.

- Figure 2 shows the relative outlines of the ATX, Full AT, and Baby AT boards. This figure uses letter callouts to show the general location of the mounting holes for the ATX, Full AT, and Baby AT form factors. The accompanying table indicates which holes are required for each form factor.
- Figure 3 shows the exact location (dimensions) of the mounting holes for ATX boards.

Must be used

All ATX board mounting locations shown in Figure 2 should be implemented for chassis assemblies to achieve full ATX 2.01 compliance and to provide proper support for the board in these areas.

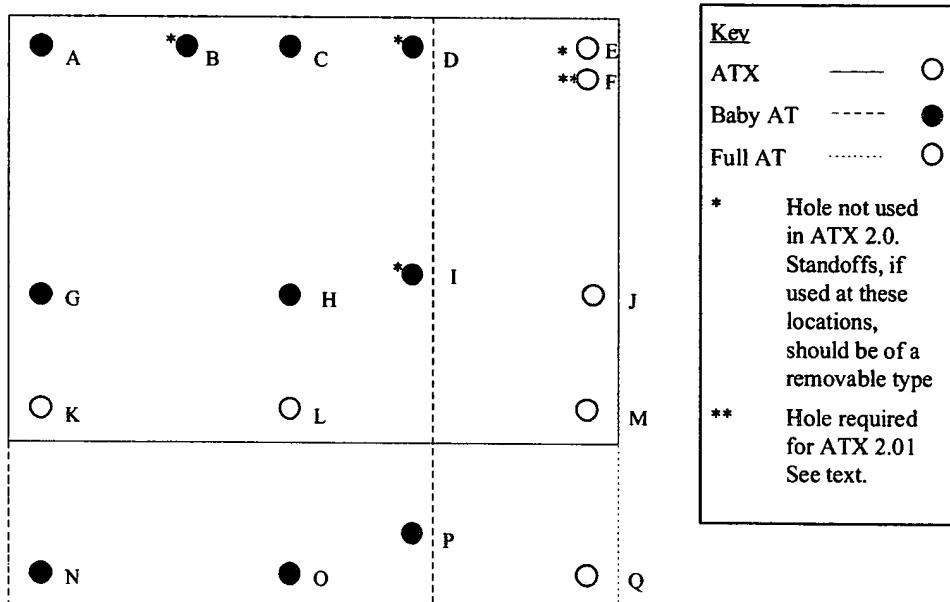
The hole at F in Figure 2 (upper right corner of the ATX board) must be implemented in all ATX 2.01 compliant chassis assemblies to accommodate boards requiring this mounting hole. This hole was labeled optional in the ATX 1.1 specification. Note that changing this mounting location from optional to required may not accommodate all ATX 1.0- and 1.1-compliant motherboards. To accommodate these motherboards, a removable standoff may be used. All ATX 2.01 compliant motherboards should implement this mounting location or allow for a standoff in this area by implementing a component and trace keepout.

No longer used

The hole at B in Figure 2 was previously required along the rear edge of the board. This location is no longer required for ATX and Mini ATX. If it is desired to implement a board mount in this area, a removable standoff should be used to avoid problems with boards that do not use this mounting location.

The hole at E in Figure 2 was recommended for ATX 1.0 and 1.1 but not for ATX 2.01. If it is desired to implement a board mount in this area, a removable standoff should be used to avoid problems with boards that do not use this mounting location.

Two holes located on the right edge of the Baby AT board (D and I in Figure 2) are not supported for ATX. Mechanical support is not required in that location on ATX, and its presence would present unwanted difficulty in placement and routing of an ATX board. Chassis standoffs in these locations should be removable, or not be implemented at all, because damage to traces on an ATX motherboard may occur.



See the mechanical drawing in this specification for details on mounting locations and board sizes

Form factor	Mounting hole locations	Notes
ATX	A, C, F, G, H, J, K, L, M	Hole at F must be implemented in all ATX 2.01-compliant chassis assemblies. It was optional in the ATX 1.1 specification. Holes at B, D, E, and I are not used in ATX; if standoffs are used at these locations, they should be of a removable type. Holes at N, O, P, and Q are not used in ATX.
Baby AT	A, B, C, D, G, H, I, N, O, P	
Full AT	A, B, C, E, G, H, J, N, O, Q	Some mounting holes for Full AT are the same as those for Baby AT and are not shown separately in the figure above. The separate AT specification defines these.

Figure 2: ATX, Baby AT, and Full AT Form-factor Mounting Holes

3.3 Connector Placement

Table 3 lists connector locations. Figure 3 clearly defines the location of the PCI and ISA connectors as well as the allowable placement area for I/O connectors on the back panel. The specification provides recommendations, but the exact locations of other connectors are left to the judgment of the motherboard designer working in conjunction with the system integrator.

Table 3: Connector Locations

Feature	Status	Comment
PCI and ISA Connector locations	Required	See Figure 3.
Power input connector location	Recommended	Right edge of board, near processor.
Power input connector pinout	Required	See Figure 11.
Optional Power connector pinout	Recommended	See Figure 13.
Disk I/O connector location	Recommended	Front edge of board, near drive bays.
Front panel I/O connector locations	Recommended	Front edge of board, right of expansion slots.
Back panel I/O panel size and location	Required	See Figure 4.
Back panel I/O connector zone	Recommended	See Figure 5.
Back panel I/O connector arrangement	Optional	See Figure 6 for example.
Memory module connector location	Recommended	Between processor and expansion slots, or between processor and disk I/O connectors.
Processor location	Recommended	Right of expansion slots, front of back panel I/O connectors.

3.3.1 Expansion slots

The ATX form-factor supports up to seven expansion slots. These slots may be any combination of ISA, PCI, or shared ISA/PCI. Figure 3 shows a typical combination of the three ISA slots, three PCI slots, and one shared ISA/PCI slot. The location of pin 1 is defined for each of the connectors. If a combination other than that shown in Figure 3 is desired, motherboard designers should extrapolate the location of pin one on each of the connectors. The slot spacing must remain constant. To allow all add-in cards to be full length, it is recommended that the height of any board component located to the left of the right edge of the seventh slot (plus clearance for the board components) be less than 0.6 inches (15.2mm). For more details on component height constraints, see section 3.4. For extra support during add-in card insertion, it is suggested that mechanical support be implemented under expansion slots through use of a device such as a bumper.

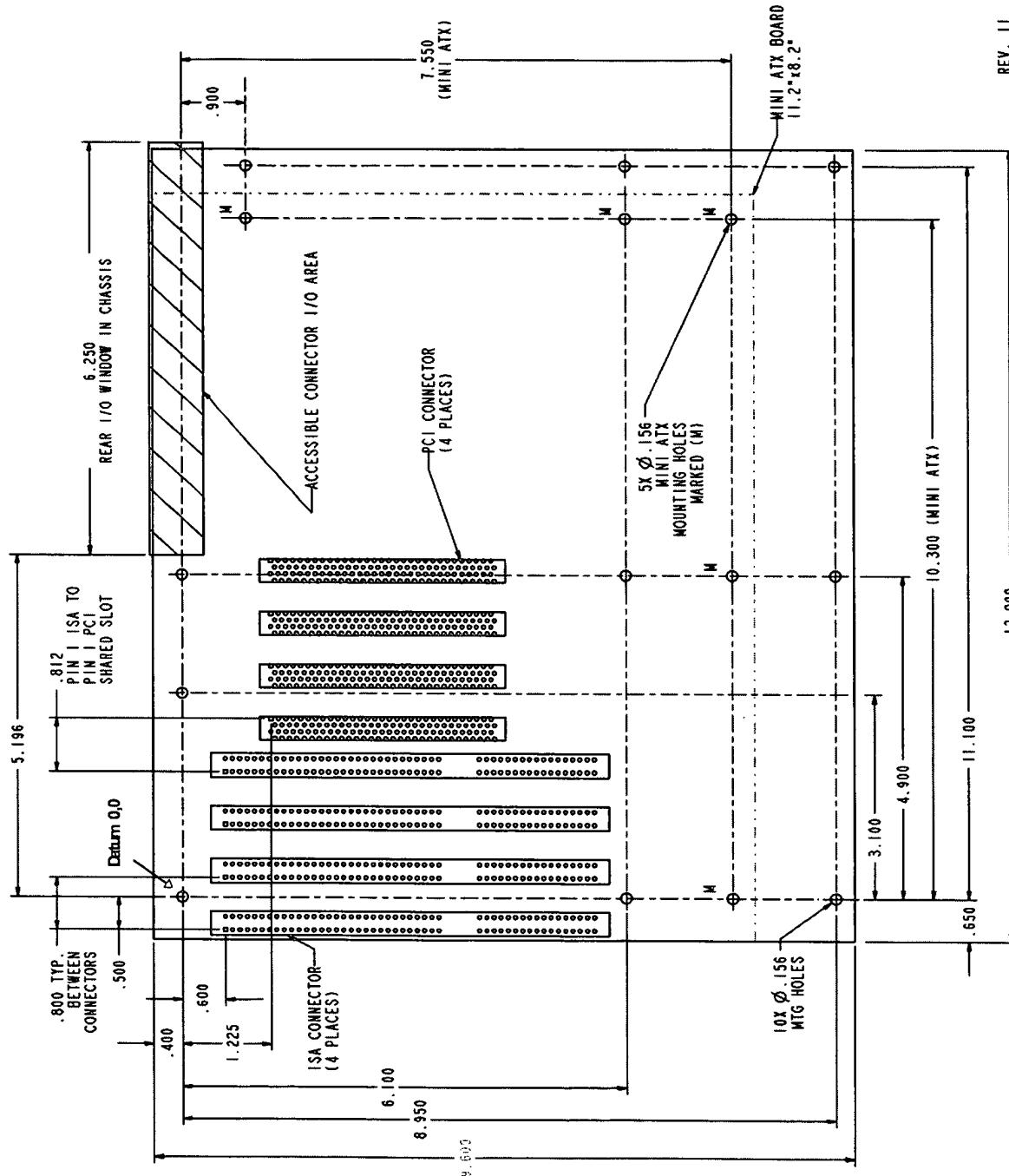


Figure 3: Sample ATX/Mini-ATX Layout Diagram
(all dimensions shown in inches)

3.3.2 Power Input

Two power supply trends are driving change in the board power input connectors. First, to support future processor technologies and the expected transition to 3.3V PCI add-in cards, a 3.3V output is required directly from the power supply. Second, with the introduction of new operating systems, such as Microsoft[†] Windows[†] 95, that support the ability to power down the system from software, a soft-power connector will increasingly become a requirement. These two changes imply that two more connectors are required (3.3V and soft-power) in addition to the two already used on power supplies today. To reduce both material and manufacturing costs, ATX combines all four of these connectors into a single 20-pin connector interface to the power supply; this interface incorporates standard $\pm 5V$, $\pm 12V$, 3.3V, and soft-power signals. Use of this connector will reduce production costs by cutting installation time and connection error rate. The connector is described in section 4.

The exact location of the power connector is not specified. It is recommended that it be placed along the right edge of the board considering the location of the processor, core logic, and clearance for the peripheral bays. Locating the power connector near the processor will help to ensure clean power.

3.3.3 Disk I/O

The exact locations of the floppy, IDE, and/or SCSI I/O connectors are not specified. It is recommended that they be placed along the front edge of the board to the right of the expansion slots. When placing connectors, the designer should keep in mind that proper clearance must be provided for the chassis peripheral bays.

3.3.4 Front Panel I/O

The exact location of the front panel I/O connector is not specified. It is recommended that it be placed along the front edge of the board to the right of the expansion slots. When placing the connector, the designer should keep in mind that proper clearance must be provided for the chassis peripheral bays. Locating the front panel I/O connector along the left edge of the board is not recommended due to limited clearance with a full length add-in card. Locating it along the front edge of the board under the expansion slots using a right angle header may be acceptable, provided that clearance for the add-in cards and mechanical retention of the mating connector is properly accounted for.

3.3.5 Back Panel I/O

With the PC platform evolving so fast, it makes sense to retain the greatest level of flexibility possible for external I/O. The multimedia explosion has demonstrated how user needs for enhanced I/O can change quickly over time. With technologies such as Universal Serial Bus and IEEE-1394 likely to quickly become standard features on PC platforms, it makes sense to retain flexibility for the future. Toward the rear of the chassis, ATX defines a stacked I/O area that is 6.25 inches (158.75mm) wide by 1.75 inches (44.45mm) tall. This area allows the use of stacked connectors on the motherboard to maximize the amount of I/O space available.

As shown in Figure 4, the bottom of the back panel opening is located 0.150 inches (3.81mm) below the top of a typical, 0.062" (1.57 mm) thick motherboard. In addition, a 0.1" (2.5 mm) keepout zone has been defined around the perimeter of the cutout area, on both the inside and outside surfaces of the chassis back panel. This required keepout zone provides a reserved space that can be used to clip a chassis-independent I/O shield to the chassis back panel. No slots, tabs, notches, or other topographical features should be placed within the keepout zone. If a feature violates the keepout zone, the chassis loses the opportunity to support an I/O shield that can be designed to fit all ATX chassis that meet the specifications listed below and detailed in Figures 4 and 5. For best EMI attenuation performance, paint should not be applied within the keepout area as it can prevent proper grounding of the I/O shield. In addition, motherboard connector placement must be limited as shown in Figure 5 to allow enough clearance between the connectors and chassis opening for the I/O shield structure.

- Nominal cutout size = 6.25" (158.75mm) by 1.75" (44.45mm). See Figure 4 for tolerances.
- Distance from top of a typical 0.062" (1.57 mm) motherboard to bottom of I/O cutout hole = 0.150" (3.81mm) (Fig. 4).
- Allowable thickness of a chassis back panel that the I/O shield can clip into is in the range 0.037" (0.94mm) to 0.052" (1.32mm) (Fig. 4).

- The corners of the I/O aperture can be rounded to a maximum radius of .039" (0.99mm) (Fig. 4). This allowable rounding of the corners helps case manufacturers extend the life of their hard tooling while still complying with the specification.
- The 0.1" (2.5mm) keepout zone around the I/O aperture area is required in an ATX 2.01 compliant chassis (Fig. 4). This allows ATX 2.01 compliant I/O shields to fit into ATX 1.1 or 2.01 compliant cases. The keepout area is needed for the shield attachment points. Avoid paint application in this area.
- The face of all I/O connectors should be placed 0.445" (11.30mm) from the reference datum and remain within the zone defined in Figure 5.
- The I/O aperture should be a simple cutout of the chassis back panel. Recessing the I/O aperture will prevent the case from accepting ATX 2.01 compliant I/O shields.

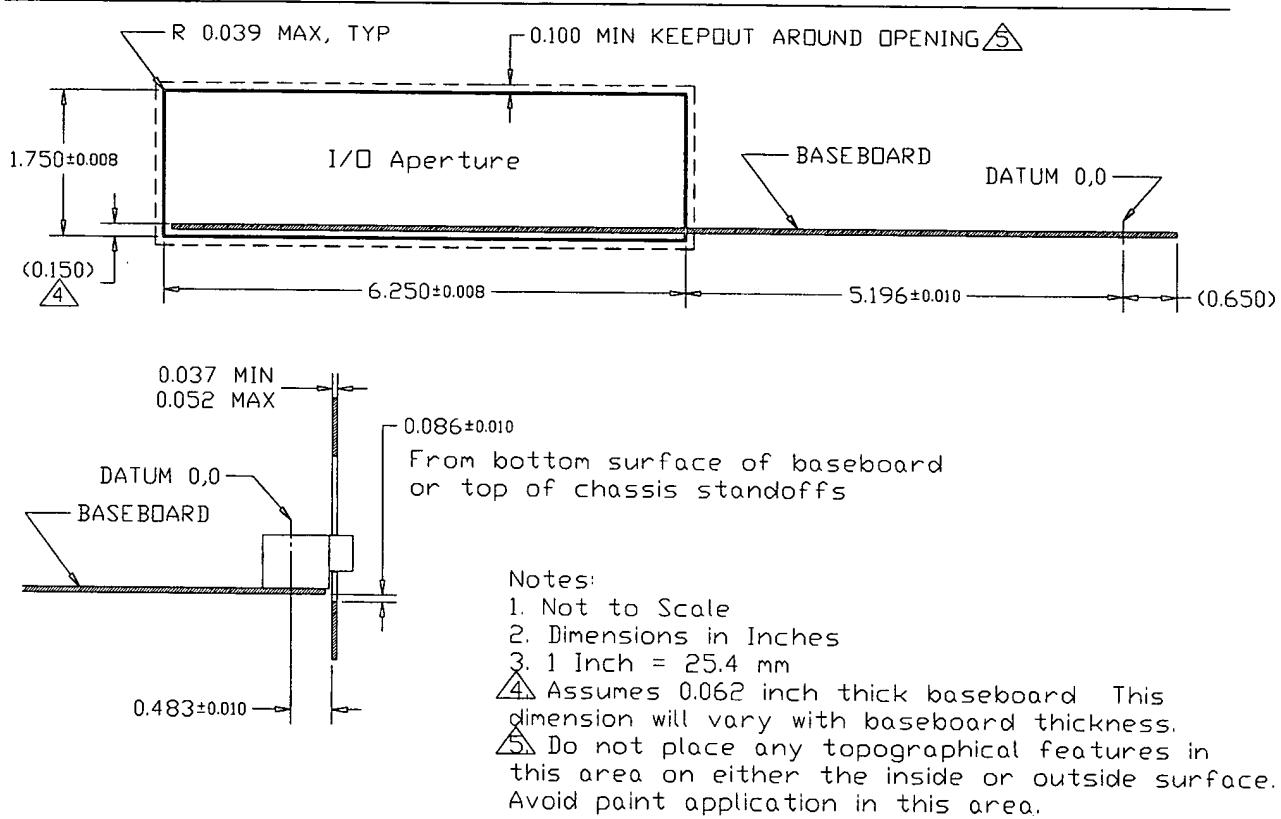


Figure 4: Chassis I/O Aperture Requirements (rear and side view—see Figure 3 for datum location)

Figure 5 specifies the I/O connector zone. Compliance with this recommendation is necessary to ensure enough clearance between the chassis aperture and baseboard connectors for the I/O shield structure. This recommendation may be waived if the shield provided with the baseboard requires less than the recommended clearance. To retain maximum flexibility, the exact positioning of connectors within the I/O connector zone is left to the discretion of the motherboard designer.

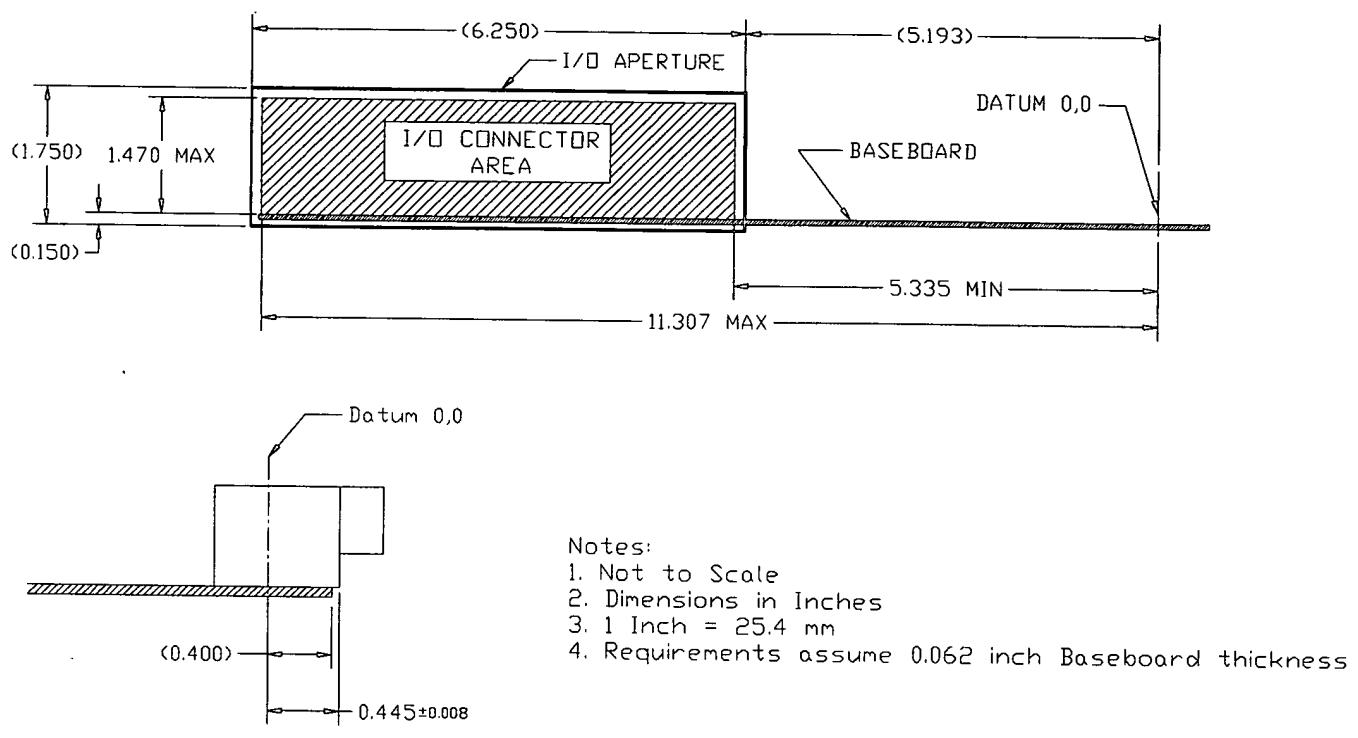


Figure 5: Baseboard I/O Connector Location Recommendation
(rear and side view—see Figure 3 for datum location)

Figure 6 shows the example multimedia I/O panel, featuring stacked serial ports, stacked keyboard and mouse, stacked audio jacks and midi port, and parallel port and VGA connector. LAN, modem, or ISDN connectors could be added if the manufacturer desired. This layout is only an example—the ATX form factor allows complete flexibility in the layout of rear panel I/O.

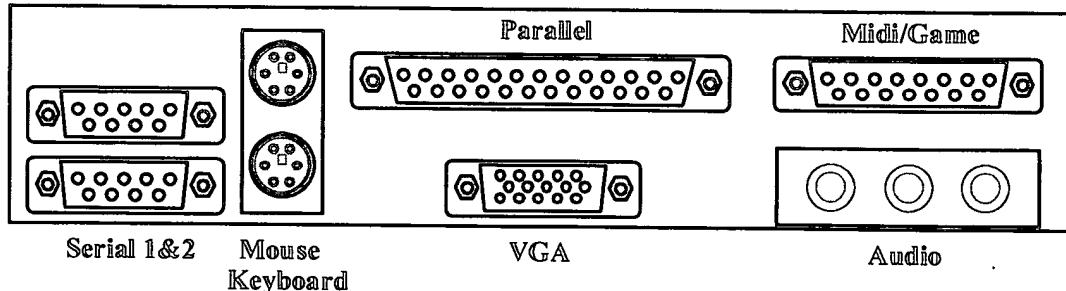


Figure 6: Example Multimedia I/O Back Panel

Figure 7: (Deleted with ATX 2.01 version)

3.3.6 Memory Sockets

The exact location of the memory sockets, whether they are SIMM, DIMM, or some other type of connector, is not rigidly specified. Ideally, the sockets should be located to the right of the seventh expansion slot and far enough toward the back edge of the board to clear the chassis peripheral bays. This will enable easy upgrade by the end user. The exact location of the sockets will be dictated by the processor and core logic placement requirements. Two of the most likely locations are

- Placed rear to front between the processor and the seventh expansion slot, or
- Placed left to right between the processor and the front edge of the board.

3.3.7 Processor

The exact location of the processor is not specified. It is recommended that it be located behind the external I/O connectors and to the right of the seventh expansion slot, so that it receives sufficient cooling. It may be cooled from either the fan located in the power supply, an active heat sink (fan attached to the processor), or normal airflow through the chassis. The exact method will depend on the specific processor cooling requirements.

3.4 Height Constraints

One of the major advantages of the ATX form factor is its accessibility and ease of expansion. Table 4 lists the status of height constraints for specific areas. Figure 8 shows the required maximum component height constraints for the components on the PC board. For full compliance with ATX 2.01, the motherboard should not encroach into these areas, which are reserved for ATX 2.01 compliant power supplies, standard peripherals, or chassis features. Similarly, ATX 2.01 compliant power supplies, peripherals, and chassis features should not extend into the motherboard component area.

⇒ **Note**

All keepout areas are now required for chassis implementations that are to be ATX 2.01 compliant. Of particular note is the revision in the component height restriction of Area A. Motherboard components in Area A were limited to 2.20" in the ATX 1.1 specification but may extend to 2.80" high in the ATX 2.01 specification.

Table 4: Height Constraints

Feature	Status	Comment
ATX Motherboard maximum component heights	Required	See Figure 8.
ATX chassis keepout in Area A	Required	3.0 inches. See Figure 8.
ATX chassis keepout in Area A	Recommended	3.5 inches. See Figure 8.

The chassis keepout for Area A must be 3.0" to facilitate dynamic considerations of components in this area on the PC board. A clearance of 3.5" is preferred above the motherboard in area A to facilitate cooling solutions that require ducting. The bottom right corner of the board is the most constrained because of the presence of 5.25" and 3.5" peripherals in some chassis configurations. Careful placement of peripherals, power supply, and chassis features will be required to maintain strict compliance to the ATX 2.01 specification.

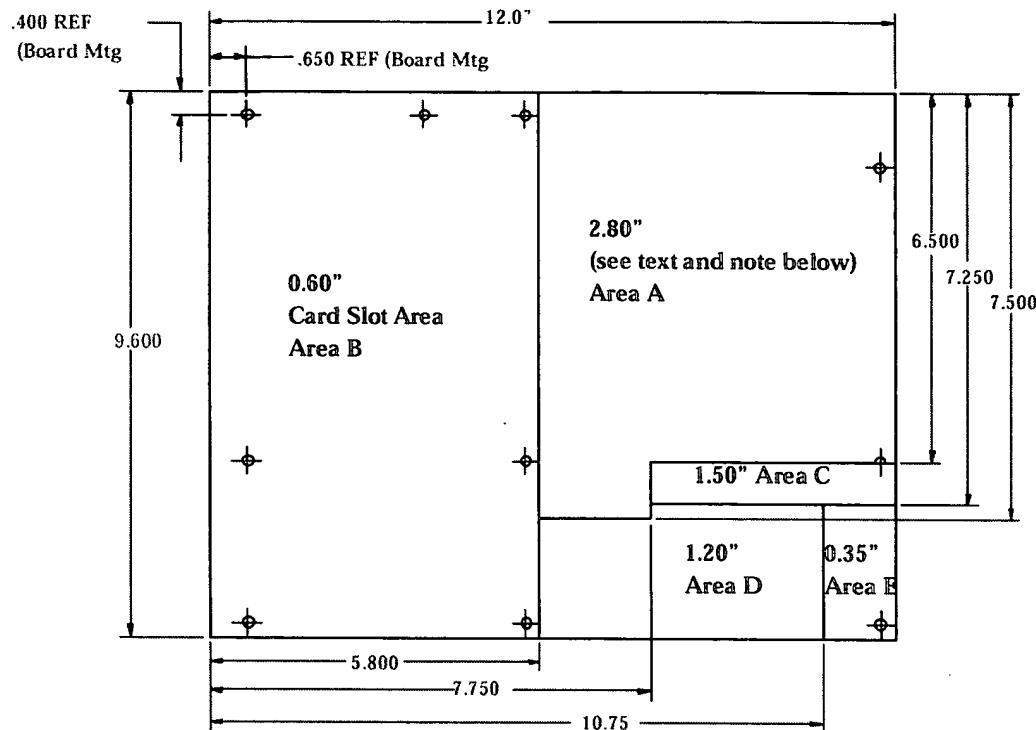


Figure 8: ATX Motherboard Maximum Component Height Restrictions
(all dimensions in inches)

Note that the 2.80" height restriction in Area A applies to the PC board component height. The required clearance for the chassis in this area is 3.0". The difference in these heights is related to the need to accommodate dynamic excursion considerations for shipping. A clearance of 3.5" is recommended to facilitate alternative processor cooling solutions.

4. ATX Power Supply

The intended location and fan direction in an ATX system is for the power supply fan to draw in cool air from outside the chassis and exhaust it directly onto the processor. In this configuration, cooling of the processor without the need of an active fan heatsink (heatsink with small fan mounted on top) is achievable in many cases (see section 4.5 for a complete discussion of power supply airflow). Table 5 lists or refers to the power supply characteristics that are required or recommended for an ATX form-factor system.

Table 5: ATX Power Supply

Feature	Status	Comment
ATX power supply overall dimensions	Required	See Figure 9.
ATX power supply cable lengths	Recommended	See Figure 16.
ATX power supply airflow	Recommended	23 CFM minimum at outlet, minimum.
ATX power supply ducting attachment features	Recommended	See Figure 10.

With some modifications, a standard PS/2[†] power supply can support an ATX form-factor system. These modifications include adding a 3.3V supply rail, PS_ON, 5VSB, repositioning of fan venting locations to move air directly across the processor, and consolidating the motherboard connectors into one 20-pin header. The preferred airflow solution is to pull air through the power supply from outside the chassis and direct it onto the processor. However, other airflow solutions may be implemented to meet the specific cooling requirements. For example, one alternative solution would be to use a standard PS/2 power supply, modified with the 20-pin power connector, without repositioning the fan but using an active fan heatsink to cool the microprocessor. Although ATX power supplies may use an external fan, care must be taken in implementing external fan configurations so the fan does not violate the keepout zones necessary for ATX 2.01 compliance (see Figure 8 for detailed keepout zones).

4.1 Power Supply Form Factor

Figure 9 shows the required overall dimensions and the general form factor of an ATX power supply without an external fan. Note that the previous version of the ATX 1.1 specification depicted a power supply with an external fan. See the previous section for discussion of external fans and keepout areas.

Future high performance processors also may require the power supply to accommodate special airflow ducting. Figure 10 suggests power supply attachment features that would accommodate the easy design of such ducting. Ducting configuration is not specified because it will depend on the relative location of the microprocessor and power supply. The location is dependent on both the chassis geometry and baseboard layout.

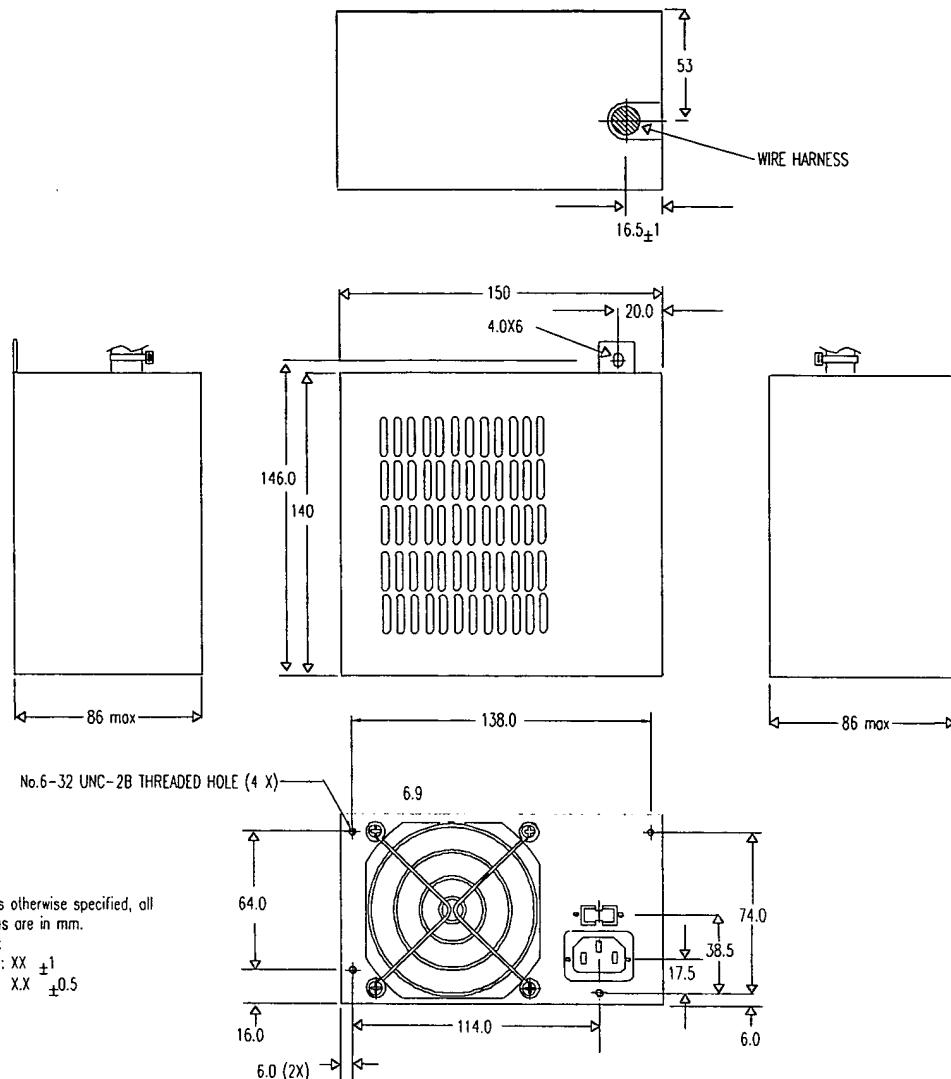


Figure 9: ATX Power Supply Mechanical Diagram
(all dimensions in millimeters)

11.0 x 5.0 cutouts (2 X) clearance under cutout minimum of 6.0 from inside cover.

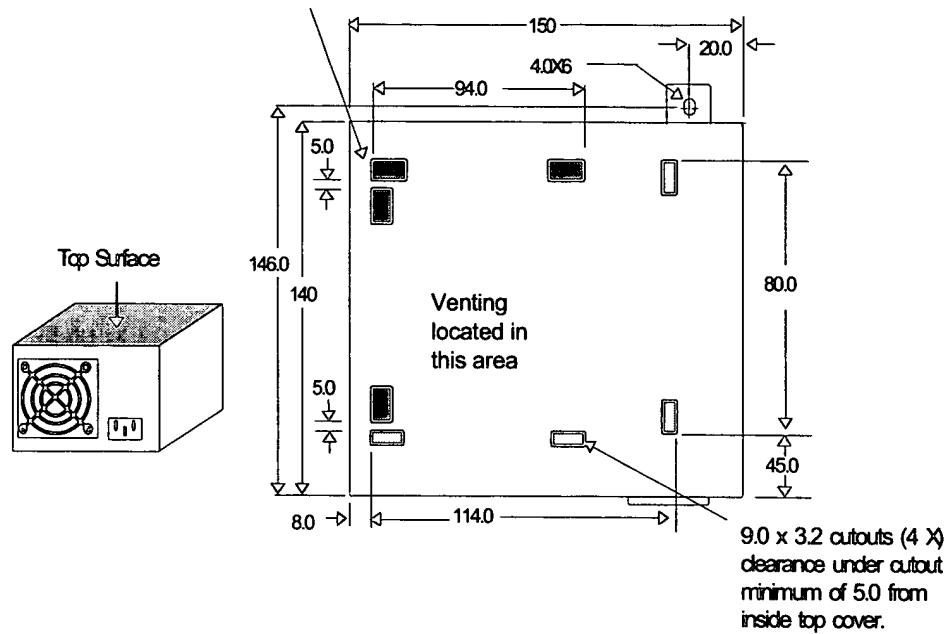


Figure 10: ATX Power Supply Duct Mounting Locations
(all dimensions in millimeters)

4.2 Power Supply Connector

Figure 11 shows the connector pinout for the main ATX power connector. This board-mounted header may be implemented with a Molex 39-29-9202 or equivalent. This mates with the power supply connector, Molex 39-01-2200 or equivalent. All signals and power rails on the main power connector are required to be implemented.

During power-up and power-down transitions, it is recommended that the 3.3VDC rails always be held at a lower potential than the +5VDC rails. This allows for improved reliability of motherboard designs at a reduced cost.

Proper implementation of PS-ON, 5VSB, and PW-OK is required for an ATX 2.01-compliant power supply.

(ALSO MAIN 3.3V SENSE)	3.3V	① ①	3.3V
	-12V	② ②	3.3V
	COM	③ ③	COM
	PS-ON	④ ④	5V
	COM	⑤ ⑤	COM
	COM	⑥ ⑥	5V
	COM	⑦ ⑦	COM
	-5V	⑧ ⑧	PW-OK
	5V	⑨ ⑨	5VSB
	5V	⑩ ⑩	12V

4.2.1 Power Signal Control Definitions

4.2.1.1 PS-ON

PS-ON is an active low signal that turns on all of the main power rails including 3.3V, 5V, -5V, 12V, and -12V power rails. When this signal is held high by the PC board or left open circuited, outputs of the power rails should not deliver current and should be held at a zero potential with respect to ground. Power should be delivered to the rails only if the PS-ON signal is held at ground potential. This signal should be held at +5VDC by a pull-up resistor internal to the power supply.

4.2.1.2 5VSB

5VSB is a standby voltage that may be used to power circuits that require power input during the powered-down state of the power rails. The 5VSB pin should deliver $5V \pm 5\%$ at a minimum of 10mA for PC board circuits to operate. Conversely, PC boards should draw no more than 10mA maximum from this pin unless a power supply with higher current capabilities is clearly specified. This power may be used to operate circuits such as soft power control. For future implementation, it is recommended that the 5VSB line be capable of delivering 720mA. This increased current will be needed for future implementations with features such as "wake on LAN."

4.2.1.3 PW-OK

PW-OK is a power good signal and should be asserted high by the power supply to indicate that the +5 VDC and +3.3 VDC outputs are above the undervoltage thresholds of the power supply. When this signal is asserted high, there should be sufficient mains energy stored by the converter to guarantee continuous power operation within specification. Conversely, when either the +5VDC or the +3.3VDC output voltages falls below the undervoltage threshold, or when mains power has been removed for a time sufficiently long so that power supply operation is no longer guaranteed, PW-OK should be deasserted to a low state. Figure 12 represents the timing characteristics of the PW-OK, PS On, and germane power rail signals.

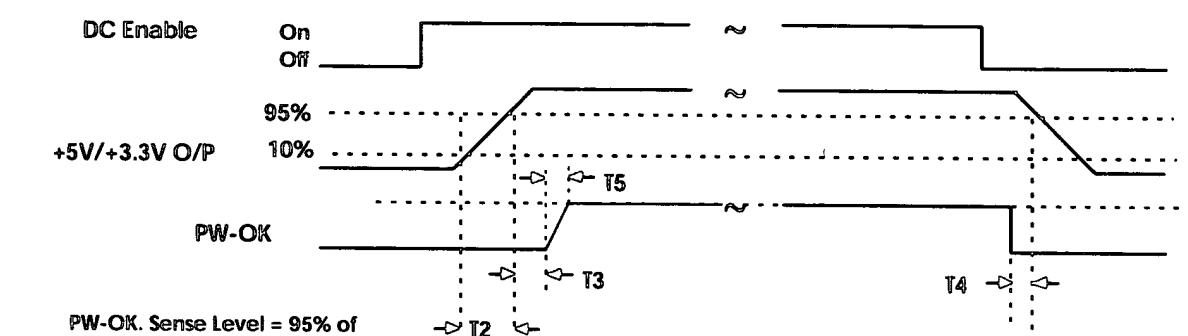


Figure 12: Timing of PS-ON, PW-OK, and Germane Voltage Rails

Although there is no requirement to meet specific timing parameters, the following signal timings are recommended:

$$2\text{ms} \leq T_2 \leq 20\text{ ms}$$

$$100\text{ ms} < T_3 < 2000\text{ ms}$$

$$T_4 > 1\text{ ms}$$

$$T_5 \leq 10\text{ms}$$

Motherboards should be designed so the signal timings recommended above are used. Using these recommendations will help drive the industry to an acceptable standard. If timings other than these are implemented or required, this information should be clearly specified.

4.2.2 Voltage Tolerances

Tolerance for the motherboard power rails should comply to the values listed in Table 6.

Table 6: Voltage Tolerances

Voltage Rail	Tolerance
+5 VDC	$\pm 5\%$
-5 VDC	$\pm 5\%$
+12 VDC	$\pm 5\%$
-12 VDC	$\pm 5\%$
+3.3 VDC	$\pm 4\%$
+5VSB	$\pm 5\%$

4.3 Optional Power Connector

In addition to the main power connector, a 2-by-3 optional connector from the power supply can be used in an ATX system for such ancillary functions as fan monitoring, fan control, IEEE-1394 power source, and a remote 3.3V sense line. Although this connector is not required for ATX compliance, it adds benefits that are compelling for a full featured system:

- The fan monitor features add the ability to monitor and detect fan failures.
- A built-in fan control allows the motherboard to request fan shutdown when the system goes into a sleep or suspend mode.
- Fan speed control is possible to allow for slower fan speeds during low power usage.

Figure 13 shows the pinout of the optional power connector. The PC board connector should be implemented with a Molex 39-30-1060 or equivalent connector. This mates with the power supply connector, Molex 39-01-2060 or equivalent. The exact location of this connector on the motherboard is not specified but should be located near the main connector for convenience.

Proper implementation of FanM, FanC, 3.3V Sense, 1394V, and 1394R is discussed below. The signals should be implemented according to these specifications if a standard optional connector is used.

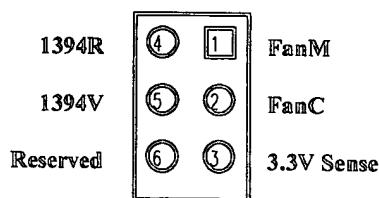


Figure 13: Optional Power Supply Connector Configuration

4.3.1 FanM Signal

The FanM signal is an open collector, 2 pulse per revolution tachometer signal from the power supply fan. The signal stops cycling during a lock rotor state; the level can be either high or low. This signal allows the system to monitor the power supply for fan speed or failures. Implementation of this signal would allow a system designer to gracefully power down the system in the case of a critical fan failure. The monitoring circuit on the motherboard should use a 1k Ohm to 10k Ohm pull up resistor for this signal. The output should be fed into a high impedance gate for the motherboard implementation. Figure 14 shows a simple illustration of the basic circuit requirements. If this signal is not implemented on the motherboard, it should not impact the power supply function.

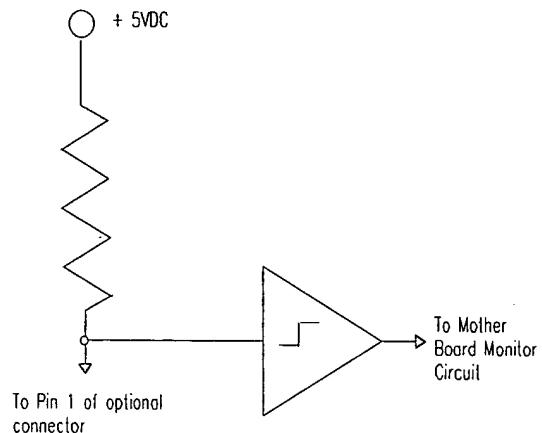


Figure 14: Simple implementation of a Fan Monitor Circuit

4.3.2 FanC Signal

The FanC signal is an optional fan speed and shutdown control signal. The fan speed and shutdown are controlled by a variable voltage on this pin. This signal allows the system to request control of the power supply fan from full speed to off. Implementation of this signal would allow a system designer to implement a request-fan-speed control or shut-down during low power states such as sleep or suspend. The control circuit on the motherboard should supply voltage to this pin from +12 VDC to 0 VDC for the fan control request.

- If a voltage level of +1 volts or less is sensed by the power supply at pin 2 of the optional connector, the fan is requested by the motherboard to shut down.
- If a voltage level of +10.5 volts or higher is being supplied to pin 2, the fan in the power supply is requested to operate at full speed.

The fan control in the power supply may be implemented so that it allows variable speed operation of the fan, depending on the voltage level supplied. If, for example, a +6 volt signal is sensed at pin 2, the power supply would operate the fan at a medium speed. If this signal is used for on/off control of the power supply fan, and speed control is not implemented in the fan control circuit of the power supply, the power supply fan should operate at full speed for any voltage level over +1 VDC. The power supply should draw no more than 20mA from pin 2 of the optional power supply connector. A pull-up should be used internal to the power supply for this signal so that if the connector is left open, the fan will be requested to operate at full speed.

Figure 15: (Deleted with ATX 2.01 version)

4.3.3 3.3V Sense Line

A remote 3.3 V sense line can be added to the optional connector to allow for accurate control of the 3.3VDC line directly at motherboard loads. Because of potential voltage drops across the connector and traces leading to the motherboard components, it may be advantageous to implement a 3.3V sense line that remotely monitors the 3.3VDC power level at the load on the motherboard. The implementation of this signal should be such that if an NC condition is detected on this line, the default 3.3V sense line on the main connector would be used for sensing the 3.3 VDC voltage level.

4.3.4 1394V Pin

This pin on the optional connector allows for implementation of a segregated voltage supply rail for use with unpowered IEEE-1394 solutions. The power derived from this pin should be used to power only 1394 connectors. The output of this power rail is dependent on the 1394 compatibility required. Use of this power rail for motherboard or other power needs may have unpredictable results, because power for 1394 devices is not required to be regulated and may provide voltage levels between 8 and 40 volts. See the applicable IEEE-1394 specification for details on the specific power requirements for this voltage rail. If this power rail is implemented, it should operate such that the main PS-ON signal must be asserted low for power to be delivered at this connector.

4.3.5 1394R Pin

The 1394R pin provides an isolated ground path for unpowered 1394 implementations. This ground should be used only for 1394 connections and should be fully isolated from other ground planes in the system.

4.4 Power Supply Wiring Recommendations

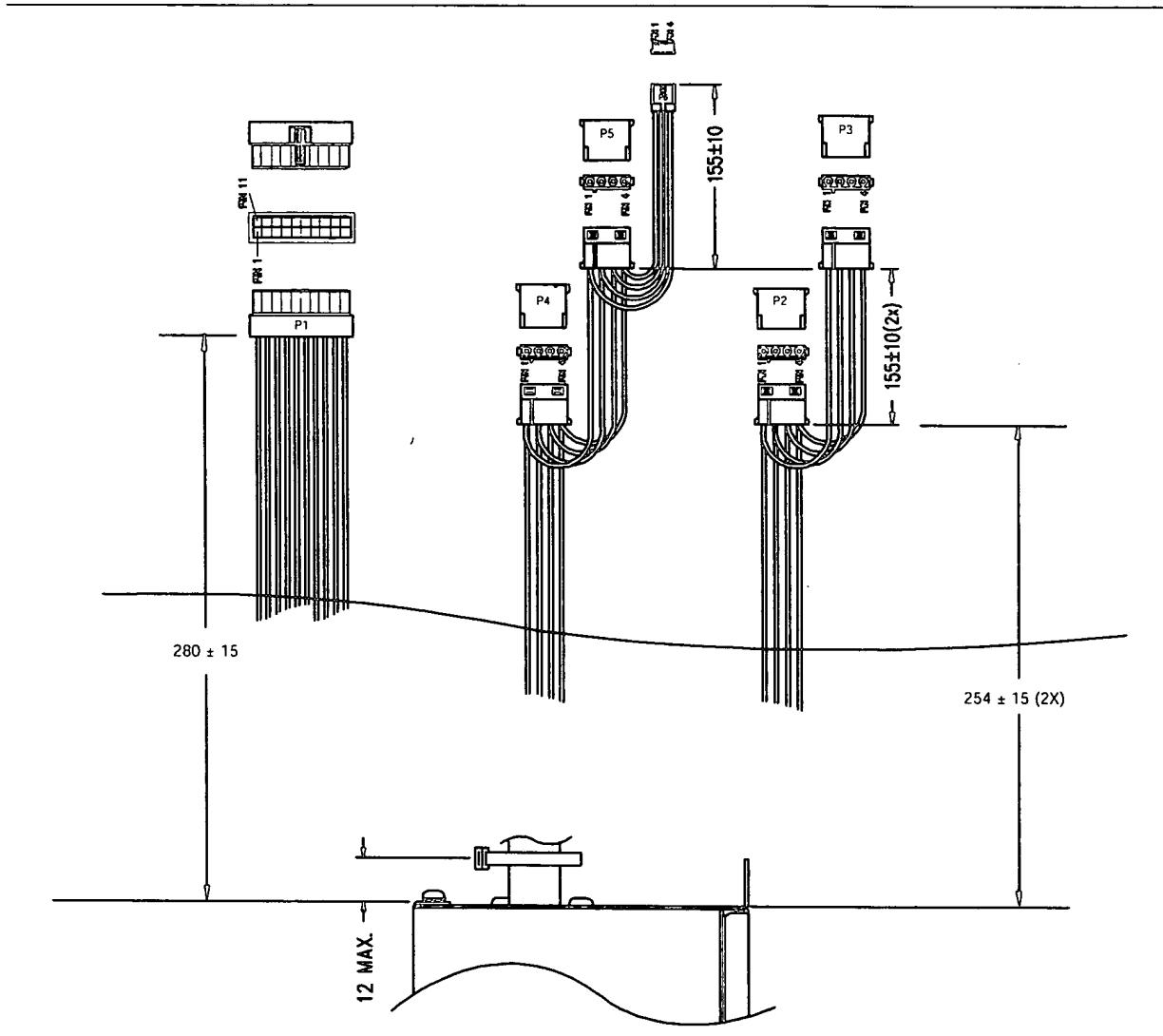
There is no specific requirement for length or color of wiring from the power supply. Tables 7 and 8 suggest wire color coding that is followed by many vendors, but this color coding is NOT required. Figure 16 demonstrates typical cabling for an ATX power supply with suggested cable lengths.

Table 7: Suggested Wire Color Code for ATX Power Supplies

18 AWG Wire	Signal	Pin	Pin	Signal	18 AWG Wire
Orange(22AWG)	+3.3 VDC	11	1	+3.3 VDC	Orange
Brown(22AWG)	3.3V sense	11			
Blue	-12 VDC	12	2	+3.3 VDC	Orange
Black	COM	13	3	COM	Black
Green	PS-ON	14	4	+5 VDC	Red
Black	COM	15	5	COM	Black
Black	COM	16	6	+5 VDC	Red
Black	COM	17	7	COM	Black
White	-5 VDC	18	8	POK	Gray
Red	+5 VDC	19	9	+5VSB	Purple
Red	+5 VDC	20	10	+12 VDC	Yellow

Table 8: Suggested Wire Color Code for Optional ATX Power Supply Connector

22 AWG Wire	Signal	Pin
White	FanM	1
White/Blue Stripe	FanC	2
White/Brown Stripe	Sense	3
NC	NC	4
White/Red Stripe	1394V	5
White/Black Stripe	1394R	6

Figure 16: ATX Power Supply Wiring Harness
(all dimensions in millimeters)

4.5 Power Supply Airflow

An ATX power supply should be designed to provide maximum airflow to cool both the power supply and key components inside the system such as the processor. The exact venting location and geometry as well as fan selection for the power supply will vary, depending on the complete system solution being implemented. The fan should allow sufficient airflow through the chassis to accommodate proper cooling. As a baseline for designing the power supply, it is recommended that 23 CFM minimum be present at the outlet of the power supply. Figure 17 shows one possible configuration for the power supply vent inside the system. The configuration for the power supply vent on the outside of the system should also provide the least possible restriction on the airflow. One recommended solution for providing the minimum impedance to airflow is to provide a wire fan grill, such as shown in Figure 17, in lieu of the common stamped sheet metal designs.

Note that tradeoffs exist between the airflow provided, acoustical noise generated by the system, and cost. Structures that attempt to control or restrict airflow will generate acoustical noise and should be designed to provide minimum noise levels achievable. Well vented systems with low flow impedance may allow the use of quieter, lower power fans or minimize the need for costly secondary fans.

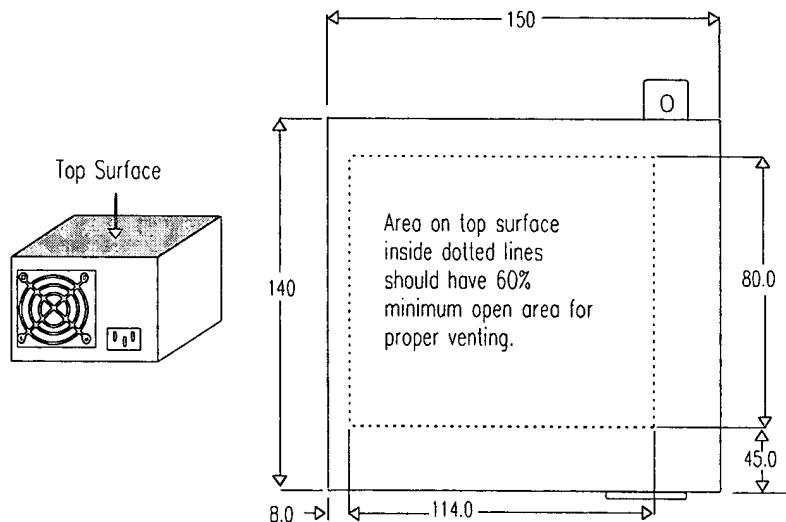


Figure 17: ATX Power Supply Suggested Venting
(all dimensions in millimeters)

5. Other ATX Chassis Considerations

An ATX-compliant chassis should be designed so that it will allow for all ATX 2.01 compliant motherboards to be integrated. Although not explicitly stated throughout the text, a chassis should implement all features necessary to properly support a complete ATX solution. Many of the chassis features are embedded in the text, but others that are related only to the chassis that will be pointed out in the following section.

5.1 Venting

Adequate venting should be provided in the system to allow for unimpeded and well directed airflow to cool key components such as the processor. One recommendation that is implicit in the ATX specification is the placement of the power supply. The power supply should be placed in close proximity to the processor if the power supply is expected to cool the processor properly (but be sure to observe the component height keepouts over the PC board). Chassis venting should be placed strategically to allow for proper cooling of other components such as peripherals and add-in cards. A secondary fan should be considered in cases where the power supply fan is incapable of cooling all system components.

5.2 Power Supply Mounting

If the power supply is mounted so that it must be removed to allow for integration of Field Replaceable Units (FRU), consideration should be made for easy removal of the power supply. Some of the typical FRU components that should be considered are the processor, memory, add-in cards, and peripherals. Use of a common fastener such as a standard screw that is easily accessible should be considered for mounting power supplies that interfere with easy component integration.